Fact Sheet: Pollution Prevention Alternatives for Ozone Layer-Depleting Solvents in Metal Parts Cleaning

By the end of 1995, the United States will unilaterally phase out the production of ozone-depleting compounds. The phase- out schedule has set forth by section 606 of the Clean Air Act Amendments of 1990 has been accelerated four years.

The production phase-out includes chloroflourocarbons such as CFC-113 and the common metal degreaser 1,1,1-trichloroethane, also known as methyl chloroform. In addition, these solvents are considered a hazardous waste when spent. This phase- out will have an enormous impact on businesses that clean metal parts and surfaces.

The production of chlorinated solvents in the U.S. was 1.7 billion pounds in 1989. There are about 528 million pounds of chlorinated solvents working in this country's 50,000 vapor degreasers.

Approximately 60% of all the solvents used in degreasers across the U.S. is the ozone-depleting solvent 1,1,1-trichloroethane.

Additional factors affecting ozone-depleting solvents include a tax on these substances to discourage their use. The tax is designed to increase over time making it more expensive to use the materials. The impending phase-out and rising tax costs of chlorinated solvents is prompting manufacturers to investigate alternatives. Despite the amount of time and money that have been devoted to research to find alternatives to chlorinated solvents, there is still no universal replacement for the wide variety of solvent uses. However, several methods in use have been found to work well for certain applications.

These alternative methods present different technical problems. Issues such as cleaning effectiveness, toxicity, flammability, material compatibility, and cost need to be addressed when selecting a solvent alternative.

The following is a brief overview of four alternatives to chlorinated solvent use in metal parts cleaning. These are: aqueous and semi- aqueous cleaning, vacuum deoiling and dry ice blasting.

Aqueous Cleaning

Aqueous cleaning solutions use water as the primary solvent. A combination of water conditioners, detergents and surfactants are added to promote better cleaning of the metal object. In addition, special additives such as builders, pH buffers, inhibitors, saponifiers, emulsifiers and deflocculants can be added to meet the desired cleaning requirements. Tap water is usually sufficient for the initial stages of aqueous cleaning followed by deionized water in the rinse stages. Ions present in the water such as calcium and magnesium can cause corrosion problems or allow deposits to form on cleaned parts. Currently there are no standard levels of water deionization, but through experimentation one can find an adequate deionization level for the particular application.

When choosing an aqueous cleaner and process it is important to analyze the configuration of the part and the characteristics of the contaminants that are to be removed. Parts can be cleaned in batches or through an in-line system. In-line equipment is characterized by high throughput cleaning requirements. Batch equipment is characterized by low throughput activities, such as maintenance applications or small production processes. The process can be further modified by the addition of immersion and spray-type equipment.

Immersion processes submerge parts into the cleaning solution.

Agitation of the parts during the wash cycle dramatically increases cleaning efficiency and can be achieved with the use of ultrasonics, mechanical agitation, or jetting actions. Agitation promotes the loosening of particulates and increases the effectiveness of the solution detergents. Spray equipment is used to clean parts that are simple in shape, such as car bodies or appliance shells. Parts are sprayed with a cleaning solution. The pressure of the spray is optimized to meet the cleaning requirements.

There can be many rinse tank arrangements for an aqueous cleaning system, but designs that incorporate cascading rinse tanks will reduce water usage. For example, if a cleaning system is using three rinse tanks, overflow from the final rinse tank is fed into the intermediate rinse tank, while overflow from the inter-mediate tank is fed into the primary rinse tank. System makeup water is supplied to the final rinse tank and overflow from the primary rinse tank is disposed of in an environmentally sound manner.

Research is being conducted on methods to further reduce water usage by closing the water cycle, thus making it a continuous process requiring little or no make-up water. Impurities remain on the parts if spots appear afterward. Spots can be the result of inefficient rinsing cycles or contaminated rinse water.

Reorganization of the rinse process or water treatment can solve this problem.

The Newark Air Force Base, located in Heath, Ohio, successfully reduced 1,1,1-trichloroethane and CFC-113 usage through the application of several aqueous cleaning technologies. Newark AFB uses an aqueous process for the precision cleaning of components of inertial guidance and navigation systems. The sophisticated parts that form the nucleus of these systems are extremely susceptible to microscopic contamination. System failure can be caused by a particle less than one micron (one millionth of a meter) in size. To meet the demand of cleanliness, the aqueous system incorporates the use of ultrasonics and highly-deionized water during the wash and rinse cycles. The cleaning solution is continuously filtered during the wash cycle to ensure the lowest level of particulate contamination.

Once the wash cycle is complete, the cleaning solution is pumped back into its holding tank and reused. The cleaning solution in the holding tank is then replaced at regular time intervals. Over a seven year period Newark AFB has decreased the amount of CFC-113 used by 72%. Newark AFB is installing ten additional aqueous cleaning centers over the next year. The goal is to phase-out the use of all ozone depleting chemicals by October 1994.

Aqueous cleaning offers an effective cleaning alternative for most parts but does have its disadvantages. With the use of water, it is important that sufficient measures are taken to prevent corrosion or scaling on parts. This can be accomplished by using deionized process water, incorporating the use of thorough drying stages, and applying appropriate rust and corrosion inhibitors.

Because particulates removed from processed parts are present in the wash and rinse baths, it is necessary for the baths to be processed to remove the contaminants. Certain types of contaminants present in the cleaning baths, such as chips, fines and some organic chemicals, may render them a hazardous waste and will have to be managed as such.

Semi-Aqueous Cleaning

Semi-aqueous cleaning products have demonstrated their efficiency to remove waxes, heavy greases, tar and baked on organic materials.

Generally semi-aqueous cleaners are effective at room temperature and they possess a very low evaporation rate which infers low use cost and low VOC emissions.

The most common semi-aqueous cleaners include terpenes and petroleum based hydrocarbons. Terpenes are compounds derived from the natural extracts of a variety of plants, such as certain tree barks and citrus fruit skins. Generally terpenes are biodegradable and noncorrosive.

These characteristics make them attractive alternative cleaners. A terpene cleaner is used typically in a cold cleaning tank. The part is immersed in the tank with agitation and then usually placed in a hot solution and dried.

Petroleum based hydrocarbons have been on the market for quite awhile. The phase-out of CFCs has caused many companies to reevaluate petroleum based hydrocarbons. Generally speaking, the petroleum based hydrocarbons are less costly but not quite as effective as terpenes for a wide range of contaminants.

Several disadvantages are associated with some semi-aqueous cleaning products. The biggest concern is flammability. Several semi-aqueous cleaners have low flash points and become extremely volatile when sprayed. Health effects associated with the use of terpenes are still

unclear. Several terpenes have been found to be a carcinogens among certain laboratory animals, but results are inconclusive for humans.

Vacuum Deoiling

A new process on the market is vacuum deoiling, an operation that removes surface oils from parts without using ozone-depleting or hazardous chemicals, water or detergents.

Thermal and vacuum technology remove the oil residue on parts through vaporization. Once the parts have been loaded the heater and pump are actuated to warm and evacuate the unit's chamber. The oil's boiling point falls with pressure so heating it in a slight vacuum dries the part quickly. The system is not designed to clean materials that do not evaporate quickly such as a solid lubricant. In most cases parts can be cleaned through this one-step process in about 20 minutes or less.

The vapors are condensed and collected for reprocessing or recycling. Hazardous waste disposal costs are reduced or eliminated in this process.

Dry Ice Blasting

This technology uses solid pellets of carbon dioxide as a blasting medium for cleaning metal parts. This process uses dry ice pellets which return to their gaseous state on impact. The process relies upon thermal shock, velocity and the lateral delivery of kinetic energy.

When the dry ice pellets impact the surface, the drop in surface temperature helps to pierce the contaminant or residue. Once contact is made with the base the kinetic energy acts laterally along the base surface lifting the residue away. The system's cleaning performance is optimized by controlling the pellet size, hardness, and quantity. In addition, the speed or flow can be controlled to tailor the system to a specific cleaning medium. In-process machinery, welding equipment, and turbines can now be cleaned on-line. This means less down-time for relocation, disassembly and masking.

Replacing chemical cleaning methods with dry ice blasting reduces harmful air emissions and enhances worker safety. Dry ice blasting also eliminates ongoing company liability associated with the use of solvent chemical wash processes. The carbon dioxide pellets disintegrate upon impact and dissipate to the atmosphere. As a result, spent solvent does not need to be disposed. Hazardous wastes such as leaded paints, PCBs and asbestos can be more easily encapsulated and disposed. Because there are no liquid solvent residues left behind, the process is considered dry, making it versatile for many applications.

Also, there is generally no addition to the volume of the produced waste stream for the cleaning process. For example, if solid carbon dioxide blasting is used for paint removal, the pellets sublime leaving the removed paint behind. The paint residues alone can then be collected, resulting in the smallest amount of waste. Since waste volumes are minimized, so are the costs associated with waste removal and disposal.

Conclusion

Numerous technologies and methods are entering the market. An advanced non-ozone-depleting vapor degreasing process has been developed that combines a solvating agent with a rinsing agent. Perflourocarbons (PFCs) are being used as an interim rinsing agent until hydroflourocarbons (HFCs) are further developed.

When replacing ozone depleting solvents companies should first examine their cleaning process for source reduction options. The parts should be examined to determine the source and characteristics of the contaminant. It may be possible to modify the production process to reduce or eliminate cleaning.

The majority of ozone depleting solvents are associated with cleaning processes, but these chemicals are also used in products such as adhesives and component coatings. Ask your vendor if solvent-free products are available. If they are not offered by your particular vendor, check with a different one. Several product vendors are attempting to produce solvent-free Semi-Aqueous Cleaning.

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